

Hawaiian hoary bat annual home range movements, habitat use, and roosting behavior

Proposal Prepared for SunEdison

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From: U. S. Geological Survey, Pacific Island Ecosystems Research Center

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Background

The Hawaiian hoary bat, *Lasiurus cinereus semotus* (Vespertilionidae), is the sole extant terrestrial mammal endemic to the Hawaiian Islands and is listed as an endangered subspecies based on apparent population declines and limited knowledge concerning distribution, abundance, and habitat requirements (U.S. Fish and Wildlife Service 1998).

Three bats were radio-tracked by Jacobs (1992) for two weeks. Jacobs found day roosts but he did not estimate home range size or habitat use. Bonaccorso et al. (2015) measured foraging range and core use areas (CUA) that provided high spatial resolution of habitat use, but with snapshots in time of 13 days or less and did not include winter ranging movements. Both Menard (2003) and Bonaccorso et al (2015 in press) demonstrated bat winter range to include high elevation areas on Hawaii documented by specimen collection and acoustic surveys respectively. Our current proposal will use radio-telemetry to track movements on Hawaii Island during both summer and winter and the composite information will more closely reflect the concept of home range described as “the area used by an animal in all its activities including sheltering, foraging, and mating” (Burt 1943) over the span of a full annual cycle.

Objectives

The objectives in this proposed study of Hawaiian hoary bats will document:

- Foraging/home range size including winter and summer ranges over two annual cycles (2 years duration of field tracking),
- seasonal movement patterns,
- habitat use,
- roost fidelity and roost tree characteristics,
- mother-pup behaviors,
- pup survival rate through fledging

All of the above objectives are listed as high priority by ESRC, USFWS, DOFAW, and USGS and included in the Sun Edison call for proposals. Each of the objectives when fulfilled will contribute to a more informed guidance toward mitigation strategies for the future selection, restoration and protection of natural reserve lands for the recovery of Hawaii hoary bats.

Methods

Radio tracking

We propose a two year radio-telemetry study on the island of Hawaii with a study area spanning the Wailoa-Wailuku-Waikaumalo watersheds from near sea-level to montane sites > 3,500 m and including the northern slope of Mauna Loa that harbors important documented

winter foraging range for Hawaiian hoary bats (Bonaccorso et al. 2015 in press). The USGS Pacific Island Ecosystems Research Center currently uses an automated telemetry system for tracking birds at long distances across difficult terrain on Hawai'i Island. Our current proposal will use the existing network of antennae masts at Hakalau Forest National Wildlife Refuge and will expand this network with additional masts to provide continuous tracking of bats across 1,500 sq km of the island's windward region (see figures).

Bats will be tagged with transmitters $\leq 5\%$ body weight (Sikes et al. 2011) that operate continuously up to 28 days (BD-2 model, Holohil Systems), as well as programmable tags offering user-defined schedules over several months (CTx Ag376 Biotrack). Sparrow System Bantam Automatic Receiving Units (ARU) will scan transmitter frequencies with 8 directional antennae while recording signal strength, date, and time used in combination with a network of 20 or 40 ft high antennae masts. Post-processing converts signal strengths into bearings and bat location is triangulated from multiple masts. Field testing has confirmed a reception range potential of 30 km. Masts will be relocated as needed to track long range bat movements.

Ground-crews will supplement the ARU tracking system using hand-held receivers to track bats to day roost locations and record fine-scale foraging movements at close range. Infrared and thermal videography will image roosting individuals, particularly recording mother-pup behavior and pup survivorship. Some bats equipped with temperature-sensitive transmitters (BD-2T, Holohil Systems) or data loggers (SRX-400, Lotek Wireless Inc.) will be monitored at day roosts to record thermoregulatory patterns and potential use of shallow torpor. Data loggers (iButton DS1921) will be record ambient temperature. Radio transmitters with a position switch (LB-2N model, Holohil Systems) will be used on some bats to produce data on flying-roosting time budgets.

Bats will be captured by mist-netting following guidelines of the American Society of Mammalogists (Sikes et al. 2011) and by USGS permits from USFWS and Hawaii DLNR with ancillary data taken on sex, morphology, reproduction, tissue and fecal collection. Seasonal patterns in habitat use and movement patterns will be derived from the movement of successive individuals across a year to quantify a composite of annual home range and population movements. Data will be analyzed with customized R software to determine spatial coordinates that will be mapped with ArcGIS to determine range size, elevation, and land-cover associations. Vegetation attributes of trees and stands used by bats as day roosts will be compared to randomly selected stands. Tree attributes will include species, diameter, height, roost aspect, elevation, and proximity to nearest road. Stand attributes will include land-cover class, composition of neighboring dominant tree species, canopy closure, and understory density. Roosts will be monitored with surveillance cameras to obtain information on mother-pup behavior, frequency and duration of foraging bouts, time budgets and pup survivorship (Winchell and Kunz 1993). Acoustic sampling at roost sites will collect information on vocalization including mother-pup communication.

Conducting this study in Eastern Hawaii offers the most dependable region known for hoary bat live capture. Nevertheless, the proposed study duration of two years will greatly enhance the opportunity to obtain statistically robust telemetry data on large numbers of bats.

Analyses

Home range – Bat locations from telemetry will be analyzed with kernel density estimators in the R package *adehabitat*. Brownian bridge movement modeling will predict trajectories of movement between successive locations (Horne et al. 2007).

Foraging habitat - Euclidean distance analysis will quantify habitat use (Conner and Plowman 2001) by comparing the mean distance of an individual's locations to each habitat type and the mean distance of a set of random locations to each habitat type. This analysis: 1) does not require explicit error modeling or equal sampling of individuals; 2) avoids habitat misclassification resulting from telemetry error; and 3) allows evaluation of surrounding habitat regardless if included within home range (Conner et al. 2003).

Roost selection and behavior – Logistic regression models will compare tree and stand characteristics at day roosts to randomly selected locations. An information theoretic model will rank variable importance. Descriptive statistics will be produced from video and acoustic observations of mother-pup interactions at roosts. Generalized linear models will examine the proportion of the night which bats spend roosting and foraging, and its relationship to reproductive condition, regional weather conditions (temperature, precipitation, wind speed and barometric pressure), moon illumination and time of year (Anthony et al. 1981).

Budget Total Requested from SunEdison: \$779,902

Budget Match from USGS: \$119,139

Budget Match from SunEdison: \$80,000

Principle Research Staff:

Project Leader: Dr. Frank Bonaccorso, USGS, has 45 years of global experience in field biology and research on bats including 11 years of field work on hoary bats in Hawaii. He has 8 peer reviewed publications in major journals involving wildlife telemetry and over 50 publications overall in animal ecology. Ph. D. University of Florida.

Co-Project Leader: Dr. Eben Paxton, USGS, has over 15 years of global experience in field biology including avian ecology, population demography, and wildlife telemetry conducted in Hawaii. He has published over 50 peer reviewed publications. Ph.D. Northern Arizona University.

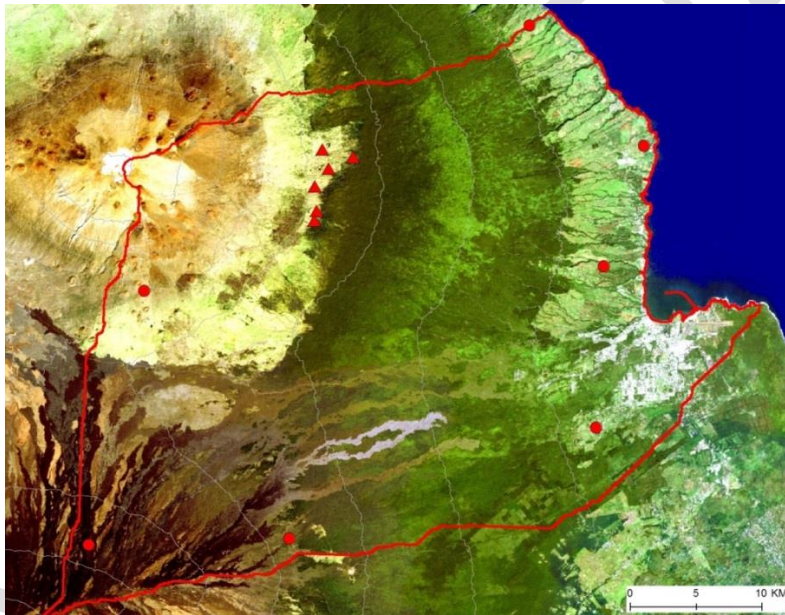
Marcos Gorresen, Quantitative Biologist, Hawaii Cooperative Studies Unit, has 20 years of global experience in vertebrate field ecology and quantitative biology including 11 years of field and modeling work on hoary bats in Hawaii. He has authored over 25 peer reviewed publications. Master's Degree, University of New Mexico.

Corinna Pinzari, Hoary Bat Conservation Biologist, Hawaii Cooperative Studies Unit, has six years of experience in working with field ecology of hoary bats in Hawaii including peer reviewed publications and technical reports. Master's Degree Candidate, University of Hawaii at Hilo.

Kristina Montoya-Aiona, Vertebrate Zoologist, has five years of experience working in the field ecology of bats including work in Hawaii on hoary bats and in the Commonwealth of the Northern Marianas working with bats. B.A. Degree, University of New Mexico.



Forty and twenty foot telemetry masts at Hakalau Forest NWR.



Existing (triangles) and proposed (circles) telemetry mast locations within the combined Waioala-Wailuku-Waikaumalo watersheds (red outline) on windward Hawai'i Island.

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